Introduction

The U.S. education system encompasses over 15,000 school districts and 88,000 public schools (NCES 1999a). Under the Constitution, educational matters are the province of the states, which delegate certain decisions to school districts or other local education agencies. Local decision making gives rise to local differences in instructional practices, which in turn yield differences in achievement. It is useful to keep this point in mind throughout the following discussion.

The statistical information presented in this chapter has been selected from representative national surveys, most of which were collected and published by the National Center for Education Statistics (NCES), an agency of the U.S. Department of Education.

Chapter Organization and Sources of Data

This chapter begins with a brief discussion of education-reform efforts that began in the 1950s. The remainder of the chapter is organized into four main sections, each addressing a critical aspect of mathematics and science education reform.

Student Achievement. This section discusses student achievement from both national and international perspectives. It is based on two primary sources of data: National Assessment of Educational Progress (NAEP) trends studies, which provide the Nation's only continuous comparable measures of student performance in four core subjects in the United States—reading, writing, mathematics, and science. They have been administered to nationally-representative samples of 9-, 13-, and 17-year-old students every two to four years since 1969. NAEP results have been reported in terms of performance levels only since 1977, which is the point where this chapter begins tracking NAEP achievement. Second, the Third International Mathematics and Science Study (TIMSS) provides information about representative samples of students in the primary and middle grades as well as students in their final year of secondary school. TIMSS includes several components: assessments in science and mathematics from 41 nations, student and teacher surveys, an analysis of curriculum guides and textbooks from 26 nations, and an observational-video study conducted in eighth grade mathematics classrooms in the United States, Germany, and Japan.

Patterns of Course Taking. This section describes the extent to which students of different gender and ethnicity completed higher-level mathematics and science courses in 1994 as compared to earlier years. The data are taken from the 1994 High School Transcript Study (HSTS). Results are based on the records of over 25,000 seniors who graduated between 1982 and 1994 (NCES 1998e).

Curriculum and Instruction. This section of the chapter discusses instructional time, curriculum and textbooks, instructional practice, and technology. Information is drawn from the curriculum and component of TIMSS as well as NCES Fast Response Surveys on telecommunications technology and classroom implementation of educational reforms.

Teachers and Teaching. This section provides an overview of teacher characteristics and qualifications, estimates of the proportion of teachers with classes outside their fields, and a discussion of new directions in teacher preparation, licensing, and professional development. Primary sources for this discussion are a recent NCES Fast Response Survey on teacher qualifications and recent educational literature pertaining to the policy aspects of teaching.

Educational Reform from the 1950s to the Present

As the National Science Foundation (NSF) celebrates its 50th year and the new millennium approaches, the Nation has identified educational reform as one of its highest priorities. Large-scale education reform in the United States has been attempted many times. However, it is quite a difficult undertaking—much more so than in other nations—due to the greater size and complexity of the U.S. system and the greater diversity of our students.

The roots of current reform efforts can be traced to developments that took place in the 1950s and 60s. Early in that era, even before the launching of Sputnik in 1957, scientists and mathematicians expressed grave concerns about the quality of precollege instruction in their fields. Among other things, they saw curricula as badly out of date and instruction as too passive for children to develop genuine understanding of the key concepts and ideas in their fields. (See sidebar, "View of Mathematics and Science Education in Elementary Schools in 1947.") With support from NSF, small groups of scientists and mathematicians began designing radically different curricula. The University of Illinois Committee on School Mathematics, under the leadership of Max Bebberman, began work on a new curriculum for high school mathematics. The Physical Science Committee, under the leadership of Jerald Zacharias, began working on new science curricula in their field (Bybee 1997, Dow 1997, and Rutherford 1997). Later, other groups of scientists came together to work on curricula for biology and chemistry.

With the launching of Sputnik, concerns about mathematics and science education reached crisis proportions. The American public joined scientists and educators in calling for reform, believing that U.S. schools were graduating too few talented scientists and engineers to assure the security of the Nation. There were two dominant views how instruction should be overhauled. Mathematicians and scientists thought the solution involved elevating academic standards and curriculum. Others argued for a return to past educational practices—reflecting a "back to basics" philosophy. The latter position was argued perhaps most vocally by Admiral Hyman Rickover, here cited by Dow (1969, 59):

> We are engaged in a grim duel. We are beginning to recognize the threat to American technical supremacy, which could materialize if Russia succeeds in her ambitious program of achieving world scientific and engineering supremacy by turning out vast numbers of well-trained scientists and engineers.

> We have let our educational problem grow far too big for comfort and safety. We are beginning to see now that we must solve it without delay.

NSF responded to the perceived crisis by expanding its work in curriculum development. With NSF support, curriculum projects proliferated in the early 1960s. (See sidebar, "National Science Foundation Support of Post-Sputnik Reforms in Science and Mathematics Education.") According to Shymansky, Kyle, and Alport (1983), the science programs were successful. By the early 1970s, NSF-funded science curricula for grades 7 through 12 were used in 60 percent of school districts and materials for elementary grades were used in 30 percent of the school districts. Because the new curricula were difficult to implement, by 1976/77, only 30 percent of districts continued to use one or more of the new science programs. New mathematics curricula fared less well, used in only 30 percent of districts in the early 1970s and in only 9 percent in 1976/77 (Bybee 1997).

The United States turned its attention to other matters until another crisis in education was declared early in the 1980s. During those years, numerous reports were published that were highly critical of the U.S. educational system. The most influential of the reports was *A Nation at Risk* (NCEE 1983):

> Our nation is at risk. Our once unchallenged prominence in commerce, industry, science, and technological innovation is being taken over by competitors throughout the world….While we can justifiably take pride in what our schools and colleges have historically accomplished and contributed to the United States and the well-being of its people, the educational foundations of our society are being eroded by a rising tide of mediocrity that threatens our very future as a nation and as a people. What was unimaginable a generation ago has begun to occur: others are matching and surpassing our educational attainments.

A Nation at Risk provided several recommendations for improving the nation's schools including increasing the requirements for graduation, increasing instructional time in core subjects, lengthening school days and school years, significantly improving teaching, and developing and implementing rigorous and measurable standards. Different initiatives were undertaken in response to these recommendations. State policy makers implemented the "new core" curriculum proposed in *A Nation at Risk*, which required four years of English, three of mathematics, three of science, three of social studies, and one-half year of computer science. High school students were required to pass exit examinations in order to receive diplomas and assure that they had command of fundamental academic skills. In the 1970s, only a handful of states required exit exams. By 1990 at least 40 states had adopted this practice (Geisinger 1992). Schools were required to develop and monitor their progress on improvement plans. More stringent screening and certification requirements were put in place in an effort to upgrade the quality of teaching (Popkewitz 1992).

Other reform initiatives focused on the structure of decisionmaking and power relationships among teachers, principals, district administrators, and parents. In many school districts, decision making was decentralized based on the assumption that those closest to the children in a school were best equipped to identify and meet the children's learning needs. School-based management and a variety of other approaches to restructuring schools were tried (Peterson 1992). New models of professional development were proposed (Sparks and Loucks-Horsley 1990, Darling-Hammond 1994) and initiatives to "professionalize" teaching were promoted, many of which focused on empowerment strategies.

The development of standards ushered in the current decade of educational reform, one that has been centered on content and instructional strategies. The National Council for Teachers of Mathematics was first to develop new standards for student learning (NCTM 1989) and teaching (NCTM 1991). The standards provided guidelines for instruction and

View of Mathematics and Science Education in Elementary Schools in 1947

It is better to teach a few things for mastery than to spread the effort over a larger number of goals, some of which are doubtful.

Present-day textbooks in arithmetic are thick and include a wide range of materials, and the unskilled teacher has difficulty determining the things that are important. The teacher may not have a clear notion (1) of the new mathematical terms that should be mastered in a given semester, (2) of the new principles that should be learned, (3) of the skills that should be gained, (4) of the concepts that should be carefully taught, and (5) of the attitudes that should be established.

[The] practical limitations to the teaching of arithmetic are

(1) the oversized classes of 30, 40, or even 50, when they should probably be held to approximately 20,

(2) failure of teachers to have and to utilize classroom materials and equipment,

(3) the tendency of teachers to forget the long trail that they themselves have traveled to arrive at generalizations and at the meaning of symbolism,

(4) the fact that many teachers undertake the teaching of arithmetic with no training in arithmetic beyond what they had in elementary school,

(5) the utilization of conflicting methods by teachers in the same school system or in the same building,

(6) the lack of specific objectives in arithmetic, and

(7) the failure of the teacher to take each pupil where he is and to provide experiences in accord with his normal growth and development.

SOURCE: Steelman, J.R. 1947. *Science and Public Policy*. Washington, DC: U.S. Government Printing Office. Reprinted 1980. The University of California, Irvine. New York: Arno Press.

National Science Foundation Support of Post-Sputnik Reforms in Science and Mathematics Education

One of the primary forces shaping the science reforms of the 1950s and 1960s was the National Science Foundation. Founded in 1950, the NSF's education effort prior to Sputnik had been confined to promoting science fairs and clubs and funding summer institutes for teachers. In 1955, the NSF annual report expressed growing concern about the shortage of high school students entering scientific careers, but was reluctant to lobby Congress for funds given the nation's historic aversion to federal influence in school matters. While the Foundation had cautiously supported Jerrold Zacharias' early planning work on PSSC Physics at M.I.T., it took the launching of Sputnik to release a torrent of federal funds.

In 1958, the NSF increased its support for curriculum development at a rapid pace; in addition to supporting PSSC, the organization funded the School Mathematics Study Group at Yale and the Biological Sciences Curriculum Study of the American Institute of Biological Sciences. Within the next two years, the organization also launched two programs in high school chemistry: the Chemical Bond Approach Project and the Chemical Education Materials Study of the American Chemical Society. By 1960, the programs of the Education Directorate represented 42 percent of the NSF annual budget. Each of these projects, at NSF's insistence, was guided by a steering committee of prominent scientists and engineers....

If the movement had lasted longer, it may have had a wider impact on schools. Unfortunately, by the end of the decade, federal support for curriculum innovation was beginning to wane … What finally killed the science reform movement, however, was the Apollo moon landing in 1969. When the world saw Neil Armstrong unfurl the American flag on the surface of the Moon, our 'education gap' seemed as mythological as the so-called 'missile gap,' and ironically congressional support for science education began to fade. Before the mid-seventies, the Education Directorate of the National Science Foundation had shrunk to 10 percent of the agency's budget, and following election of President Reagan in 1980, the Directorate closed altogether. The Sputnik reforms were to prove as ephemeral as the technological threat that spawned them.

SOURCE: Dow, P. 1997. "Sputnik Revisited: Historical Perspectives on Science Reform. Prepared for the symposium, "Reflecting on Sputnik: Linking the Past, Present, and Future of Educational Reform." Washington, DC. October 4.

learning, building upon earlier reports issued by the Mathematics and Science Education Board (MSEB) of the National Research Council (NRC) and the Mathematical Association of America (MAA). The science standards followed several years later (NRC 1996). Although not formally released by the NRC until 1995, the science education standards reflected a consensus arrived at earlier and built upon work of the National Science Teachers Association (NSTA) and the American Association for the Advancement of Science (Rutherford and Algren 1990). The seminal reports of these associations are included in the list of references (NSTA 1992, NRC 1996, and AAAS 1999a,b).

Central to standards in both subjects is the idea that students must become what Robert Glaser has described as "mindful architects of their own knowledge" (cited in Maloy 1993). In this constructivist view, students play a proactive role in their learning, rather than passively receiving information doled out by teachers or textbooks. The teacher's primary role is to facilitate and support the process by creating opportunities for students to engage in higher-level processes—solve novel problems, integrate information, and actively build their own understanding of a particular idea or situation (Anderson 1996). The standards for mathematics and science, share several basic tenets, including:

- ♦ promoting high expectations for all students;
- ♦ emphasizing depth rather than breadth of content coverage; and
- ♦ emphasizing tasks that provide students the opportunity to become actively engaged with the subject matter, problem solving, and applying skills learned in new, broader contexts.

Many of the core ideas underlying new educational standards in science and mathematics are legacies of the 1960s reform agenda, but there are important differences. One such difference is that the factor motivating change during the post-Sputnik years was the perceived need to expand the pool of potential scientists. Consequently, curricula developed during that period targeted students at the higher end of the achievement spectrum. By contrast, as educational reform evolved in the late 1980s and early 1990s, there was a genuine interest in providing a high quality education for all students. In contemporary reforms, equity and excellence are treated as equally important goals (DeBoer 1997 and Rutherford 1997).

Current reform efforts differ from earlier attempts in the breadth of their activity. From the 1960s through the 1980s, many reform strategies were pursued in isolation: some approaches focused solely on curriculum, some focused solely on structural change, and some focused exclusively on teachers. In the 1990s, the idea that all parts of the education system must be changed to meet new standards and goals was formalized in an often-cited publication by Smith and O'Day (1991), which put forward the notion of "systemic" approaches to reform. Such methods are grounded in three core ideas:

promotion of high standards for all students, purposeful alignment of policies to support good instructional outcomes, and restructuring of governance systems around the goal of improved achievement (Smith and O'Day 1991).

The sidebar, "Systemic Reform: Complex Solutions to Complex Problems," describes the intricacies involved in systemic reform, as conceptualized by NSF in the late 1970s, although the term "systemic reform" was not yet in common use.

Federal agencies have actively supported systemic reform, with the systemic initiatives funded by NSF among the best known efforts. In the first cycle of the program, NSF awarded grants to support state level reforms aimed at improving instruction and raising academic achievement. Later, the program was extended to support systemic reform in urban communities, then in rural communities, and most recently, local reform at the school district level. The U.S. Department of Education's Eisenhower Initiatives complemented these efforts, providing funds for the kind of high quality professional development needed to achieve high standards.

Legislation, particularly the "Goals 2000: Educate America Act," has bolstered the idea of large-scale reform. At the core of Goals 2000 are the eight National Education Goals that grew out of educational summits organized by the nation's governors, then-President Bush and later, President Clinton. The national goals as they appear in the legislation are presented in the sidebar, "The National Education Goals."

The legislation provides funds for states to pursue national goals through comprehensive reform efforts that encompass development and implementation of challenging standards, content, and assessments; strengthening professional development; and aligning governance strategies and accountability systems to be consistent with academic goals (Landess 1996).

The Social Context of Education

Learning experiences in schools, as elsewhere, are conditioned by the social context in which they occur. For schools, social context is greatly influenced by characteristics of the children in attendance. School enrollment is viewed as an indicator of the demand for teachers, facilities, and resources. In 1950, approximately 25 million students were enrolled in public elementary and secondary schools (NCES 1998a). The 1999 enrollment is expected to include 33.7 million elementary school students and 13.5 million secondary students. Public school enrollment is projected to be 48 million students by the year 2009 (NCES 1999a). (See figure 5-1 and text table 5-1.)

The composition and diversity of the school population have increased in the last several decades and projections suggest that these trends will continue into the 21st century. Hispanic students made up 7 percent of the school population in

Systemic Reform: Complex Solutions to Complex Problems

….[T]here are too many complex, interconnected problems present for any one, simple solution to alter the fundamental dynamics of teaching and learning in the overall education system or even a single classroom…. Clear standards for science education…that give life and meaning to classroom practice are an important part of the answer, but real, sustainable change demands much more:

- A transformation of people's beliefs about science education well informed by the processes of science and by our evolving understanding of children's ability to learn complex, thought-provoking material;
- The creation in each district and school of a clear vision of effective science teaching and a set of goals that reflects this evolving knowledge;
- High-quality instructional materials that support a coherent presentation of important science concepts—and the resources necessary to make those materials available to every student;
- New kinds of tests that more accurately measure students' deep understanding of ideas, not just their short-term recall of facts;
- A long-term commitment of professional development to a generation of educators capable of turning this vision of teaching and learning into reality;
- A broadening of public understanding and support for effective science education and the development of community partnerships that spur schools, universities, museums, foundations, and corporations to work toward common goals;
- Steadfast support from district administrators and policymakers who recognize the crucial importance of local school-based initiatives;
- Enlightened leadership that understands how all of these factors affect and depend upon each other; and
- The need for all of these changes to occur at the same time.

This is the soul of a systemic approach to science education reform: a wide-angle view of school change that sees all aspects of the system as a whole. It recognizes that if changes are to be long lasting, each and every component part of the system must be irreversibly and permanently altered.

SOURCE: National Science Foundation (NSF). 1997a. "Foundations: A Monograph for Professionals in Science, Mathematics, and Technology Education." In *The Challenge and Promise of K-8 Science Education Reform, Volume 1*. NSF 97-76. Washington, DC.

The National Education Goals

By the year 2000:

1) All children in America will start school ready to learn.

2) The high school graduation rate will increase to 90 percent.

3) American students will leave grades 4, 8, and 12 having demonstrated competency in challenging subject matter…including mathematics and science.

4) The Nation's teaching force will have access to programs for the continued improvement of their professional skills and the opportunity to acquire the knowledge and skills needed to instruct and prepare all American students for the next century.

5) U.S. students will be first in the world in mathematics and science achievement.

6) Every adult American will be literate and will possess the knowledge and skills necessary to compete in a global economy and exercise the rights of citizenship.

7) Every school in the United States will be free of drugs, violence, and the unauthorized presence of firearms and alcohol and will offer a disciplined environment conducive to learning.

8) Every school will promote partnerships that will increase parental involvement and participation in promoting the social, emotional, and academic growth of children.

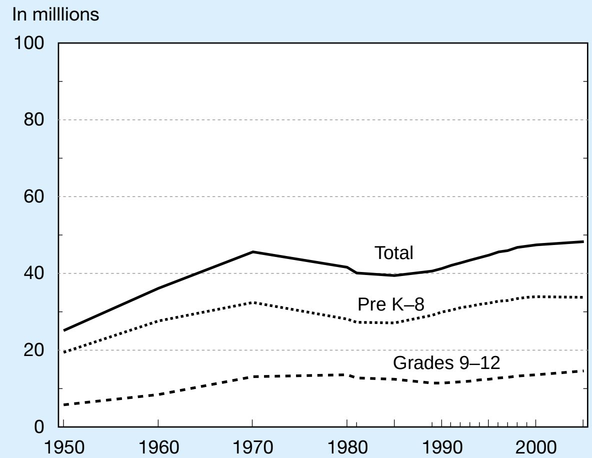
SOURCE: U.S. Department of Education. 1999. Educational Excellence for All Children Act of 1999. Fact sheet. Available from <<http://www.ed/gov/offices/OESE/ESEA/factsheet.html>>. Accessed August 12, 1999.

1979 and 14 percent in 1996. Growth in the percentage of black students in the public school population was more modest: 15 percent in 1970, 16 percent in 1979, and 17 percent in 1995, with concentrations of both ethnic groups much higher in central city schools. In 1996, approximately 32 percent of students in central city schools were black and 25 percent were Hispanic (NCES 1999c). (See text table 5-2.)

More language diversity has been introduced into schools as the number of immigrant and Hispanic students has increased. Recent data show more school-aged children now live in non-English speaking homes than ever before. That number has increased steadily from 2.9 million in 1980 to 4.2 million in 1990 (NCES 1998b).

Several family characteristics associated with school success also have changed in recent years. Mothers of younger children were better educated in 1997 than in 1972. Fewer mothers had less than a high school diploma, a decrease from 34 percent to 16 percent over that period, and more mothers were employed, 38 percent in 1972 vs. 66 percent in 1997. Fewer children lived in large families (four or more siblings),

Figure 5-1.
Total enrollment in public elementary and secondary schools: 1950–2005



SOURCE: U.S. Department of Education, National Center for Education Statistics, Statistics of State School Systems; Statistics of Public Elementary and Secondary School Systems; Statistics of Nonpublic Elementary and Secondary Schools; Projections of Education Statistics to 2007; Common Core of Data. National Center for Education Statistics (NCES). 1999. *Digest of Education Statistics,* 1998. NCES 1999-036. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

See appendix table 5-1. *Science & Engineering Indicators – 2000*

Text table 5-1.
Total enrollment in public elementary and secondary schools: 1981–2009, selected years

Year	Total	Prekindergarten through grade 8 (in thousands)	Grades 9 through 12
Fall 1981	40,044	27,280	12,764
Fall 1985	39,422	27,034	12,388
Fall 1990	41,217	29,878	11,338
Fall 1995	44,840	32,341	12,500
Fall 1999[a]	47,244	33,701	13,543
Fall 2000[a]	47,533	33,875	13,658
Fall 2005[a]	48,392	33,723	14,669
Fall 2009[a]	48,126	33,427	14,699

[a]Projected.

SOURCE: National Center for Education Statistics (NCES). 1999. *Projections of Education Statistics to 2009.* NCES 1999-038. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

Science & Engineering Indicators – 2000

Text table 5-2.
Percentage of students in grades 1–12 who are black or Hispanic in all public schools and public schools within central cities: 1970–96, selected years

	Black		Hispanic	
Year	Total	Central cities	Total	Central cities
1970	14.8	32.5	—	—
1979	16.1	35.8	6.8	14.0
1985	17.0	36.0	10.1	21.5
1990	16.5	33.1	11.6	19.8
1994	16.8	33.0	13.4	24.7
1995	17.1	31.8	14.0	24.3
1996	17.0	31.9	14.3	25.0

SOURCE: National Center for Education Statistics (NCES). 1999. *The Condition of Education, 1999.* NCES 1999-022. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

— Not available

Science & Engineering Indicators – 2000

a decrease from 24 percent to 6 percent. (See appendix table 5-4.)

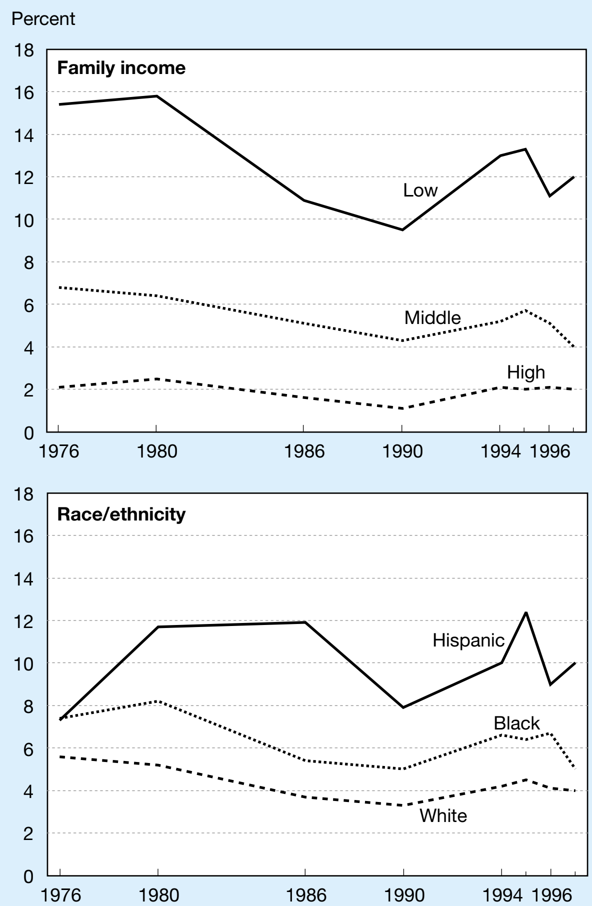
Not all changes reflected improved circumstances. Median family income[1] dropped from $38,000 in 1989 to approximately $35,000 in 1995 and 1996 (Peterson 1992) and the number of poor children has increased. In 1970, approximately 10 million children under 18 years of age (15 percent) lived in families with earnings below the poverty level. In 1996, 14 million children (20 percent) lived in poverty. (See appendix table 5-1.) Black and Hispanic children were more likely to live in poverty than white children. For example, in 1996, approximately 40 percent of black and Hispanic children (4.4 and 4.1 million, respectively) lived below the poverty line, compared to 16 percent of white children (8.5 million).

Although diversity adds richness to the learning environment, it also presents special challenges. Poor and minority children and children with limited English proficiency are more likely to experience difficulty in the early grades, to repeat a grade, or to need special education services (NCES 1998b). Black, Hispanic, and low-income students also are more likely to leave school without a high school diploma. (See figure 5-2.) Of those who complete high school, black students and low income students are less likely to enroll in college following graduation (NCES 1999c).

Additionally, families are more mobile, another factor related to poor school outcomes. The National Center for Education Statistics (NCES) estimates that one in three students changes schools more than once between first and eighth grades (NSB 1999). These moves sometimes seriously disrupt the continuity of learning, making it difficult for teachers in the new schools to identify and meet the academic needs of these highly mobile students (Kelly, Suzuki, and Gaillard 1999; NSB 1999).

As the National Science Board (1999) pointed out, responding to these challenges may be the most difficult task faced by schools and teachers in the next century. In their view, it is no longer acceptable for race, ethnicity, gender, language, or

Figure 5-2.
Percentage of 15 to 24-year-olds (grades 10–12) who dropped out of school, by family income and race/ethnicity: 1976–97



SOURCE: National Center for Education Statistics (NCES). 1998. *The Condition of Education 1998.* NCES 98-013. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

See appendix tables 5-2 and 5-3.

Science & Engineering Indicators – 2000

[1]Median incomes are computed in 1996 dollars adjusted by the Consumer Price Index.

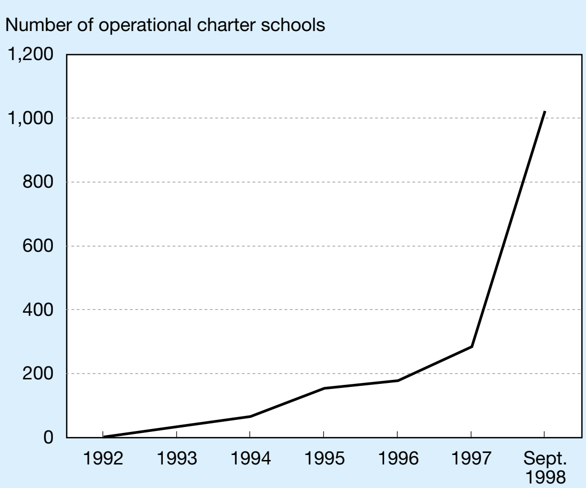
economic disadvantage to be used as excuses for the poor academic achievement of particular groups of children.

Schooling and School Choice in the 21st Century

Even with the thrust toward national standards and national goals—and perhaps in some cases *because* of that thrust—the balance of control over education is changing rapidly as the 21st century approaches. Where the option is available, many parents are enrolling their children in charter schools. Charter schools operate under a contract (or charter) with a public agency, most often a local school district. The charter frees the school from state and local regulations that might otherwise limit their use of innovative approaches to instruction. In return, the school agrees to meet specific achievement goals within a specific time period, usually three to five years. If the targets are not met, the charter is not renewed.

The number of charter schools varied considerably over states in 1998, from 5 or less in Mississippi, Hawaii, Rhode Island, Nevada, New Mexico, Delaware, and South Carolina, to over 100 in California, Michigan and Arizona (CSU 1998). In the years since the first two charter schools opened in Minnesota in 1992, the number of schools operating by charter has grown steadily. (See figure 5-3 and appendix table 5-5). Currently, the number of charter schools in operation is estimated at between 1,022 (Berman 1998) and 1,200 (Hadderman 1998 and CER 1999) nationwide. According to recent estimates, these schools serve 170,000 students, still a small proportion of the approximately 47 million elementary and secondary students in the United States.

Figure 5-3.
Charter schools by year



SOURCE: California State University (CSU). 1998. *Charter Schools: National Concept, California Experience.* Proceedings of a roundtable discussion sponsored by the California Education Policy Seminar and the California State University Institute for Education Reform. Sacramento, CA. October 1.

See appendix table 5-5. *Science & Engineering Indicators – 2000*

Educational vouchers are another mechanism for choice. The idea was first proposed in the 1950s by economist Milton Friedman, who argued that schools would upgrade the quality of their offerings (or go out of business) if they had to compete for students and resources (Hadderman 1998). Today, vouchers are promoted as a way to move central city children from failing schools to more successful schools. But vouchers remain controversial on several fronts. One of the most contentious issues is whether large-scale voucher systems will deplete much needed resources from public schools. Another point of dispute centers on the appropriateness and legality of using public funds to send children to private and religious schools. A number of privately-financed voucher plans, generally given in the form of scholarships, also have made an appearance in recent years. According to estimates, in 1992/93 approximately 4,100 privately-financed scholarships were offered to low-income students in four urban districts; in 1996/97, close to 11,000 needy students in 28 urban districts received private scholarships (Hadderman 1998).

Home-schooling also has increased in recent years—from an estimated 250,000 to 350,000 students nationwide in 1991/92 to approximately 700,000 to 750,000 students in 1995/96 (Lines 1996). Home schooling is generally seen as the ultimate form of school choice. In the 1970s, home schooling was a prevalent choice among families committed to a philosophy of child-led learning. Later, families chose to educate their children at home for religious reasons. Currently, issues of school safety and local control over curriculum also are prompting more parents to choose this alternative (Lines 1996). Students taught at home generally attend a campus-based school at least part-time for special subjects and special activities. Community resources and nearby colleges are drawn on to round out home programs of study (Lines 1996).

Although almost all states require families to register their children as "home schoolers," other regulations vary by state. Some states require parents to submit instructional plans for home-schooled students to the local or state education agency. Some require home-schooled children to participate in state testing programs. Few regulations exist, however, to assure that parents have some minimal level of educational experience in order to teach their own children at home. In most states, parents are not required to have teaching certificates to educate their own children at home**.** Michigan, which has the most stringent regulations, only requires the involvement of a certified teacher.

To date, few systematic studies have been conducted to determine achievement outcomes in charter schools. Published results have not been consistent from place to place or from one study to another. By contrast, home schooling has shown consistently positive results. In virtually every comparative study undertaken, home-schooled students outperformed their public schools counterparts. This finding is viewed with some caution however, because by necessity, data are available only from states that require home-schooled children to participate in testing programs (Lines 1996). No large-scale studies of voucher programs have been conducted, but that situation will soon change. In response to a request by the U.S. Department of Education, the National Research Council has proposed a comprehensive study that will not only examine the achievement of students whose education is financed or supplemented by vouchers, but will also examine the policy consequences, such as the impact vouchers have on the public school system (White 1999).

Student Achievement

Trends in National Achievement

The National Assessment of Educational Progress (NAEP) has monitored educational performance through its trends series (which is distinguished from other NAEP series) since 1969. To facilitate comparisons, the same instruments have been used in every trend assessment since that time. NAEP trend results are reported in terms of average scale scores and in terms of five proficiency levels or anchor points. The five anchor points correspond to five levels of performance, ranging from the basic skills and knowledge to be mastered in the earliest years (Skill Level 150) to the fluency needed to solve challenging problems (Level 350). Most of the NAEP results included in this chapter are based on the latter. (See sidebar, "Proficiency Levels Used in NAEP Science and Mathematics Trends Assessments.")

NAEP trends results from the last 20 years indicate that, for the most part, students are performing at higher levels in mathematics and science than did their counterparts in the late 1970s. However, the data also suggest that performance falls below expectations based on new educational standards (NCES 1997a).

Elementary and Middle School Science and Mathematics

At the high school level, the primary function of the mathematics and science curricula is to begin the preparation of future scientists, mathematicians, and engineers, which was the goal of educational reforms in the 1960s. In turn, the primary function of elementary and middle school science and mathematics is to lay the groundwork for high school curricula in these areas. In other words, elementary and middle schools are expected to provide the building blocks that students will need in order to progress through the science and engineering pipeline in later years. These early years are quite critical, particularly for mathematics. According to several respected educators, it is in elementary school that young children begin constructing a knowledge base to build upon as they progress to higher levels of knowledge, skill, and understanding (Campbell and Johnson 1995). This section of the chapter examines the adequacy of elementary, middle, and high school preparation, as reflected by NAEP achievement results.

The science and mathematics achievement of both 9- and 13-year-old students has improved significantly since 1977/78. In science, about two-thirds of 9-year-olds reached Level

Proficiency Levels Used in NAEP Science and Mathematics Trends Assessments

Level	Science	Mathematics
350	**Integrates Specialized Scientific Information** Can infer relationships and draw conclusions using detailed scientific knowledge.	**Multistep Problem Solving and Algebra** Can solve multistep problems and use algebra.
300	**Analyzes Scientific Procedures and Data** Has some detailed scientific knowledge and can evaluate the appropriateness of scientific procedures.	**Moderately Complex Procedures and Reasoning** Can compute with decimals, fractions, and percents; recognize geometric figures; solve simple equations; and use logical reasoning to solve problems.
250	**Applies General Scientific Information** Understands and applies general information from the life and physical sciences.	**Numerical Operations and Beginning Problem Solving** Can add, subtract, multiply, and divide using whole numbers and can solve one-step problems.
200	**Understands Simple Scientific Principles** Understands some simple principles and has some knowledge, particularly about physical sciences.	**Beginning Skills and Understanding** Can add and subtract two-digit numbers and recognize relationships among coins.
150	**Knows Everyday Science Facts** Knows some general science facts.	**Simple Arithmetic Facts** Knows some addition and subtraction facts.

SOURCE: National Center for Education Statistics (NCES). 1997. NAEP 1996 Trends in Academic Progress. NCES 97-985. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.